

# Claims

- [c1] 1. A mechanical resonator pair comprising, at least:  
a first mechanical resonator comprising, at least:  
a resonating mass;  
a driving mechanism through which the resonating mass of said first mechanical resonator is driven to resonate along a pre-selected axis;  
a driving feedback mechanism that provides status information of the resonance of said first mechanical resonator along the pre-selected axis (such as amplitude, frequency, and phase of the resonance);  
a second mechanical resonator with its resonance phase-locked to the resonance of said first mechanical resonator with certain preset phase difference comprising, at least:  
a resonating mass;  
a driving mechanism through which the resonating mass of said second mechanical resonator is driven to resonate along the same pre-selected axis of said first mechanical resonator;  
a driving feedback mechanism that provides status information of the resonance of said second mechanical resonator along the pre-selected axis (such

as amplitude, frequency, and phase of the resonance);

a frequency adjustment mechanism through which the natural resonant frequency for the resonance along the pre-selected axis of said second mechanical resonator can be adjusted by a signal;

[c2] 2. A mechanical resonator pair of Claim 1, further comprising, at least:

a circuitry that enables the phase-lock between the resonance of the first mechanical resonator and the resonance of the second mechanical resonator with certain preset phase difference comprising, at least:

a feedback control block that enables the first mechanical resonator to resonate along the pre-selected axis at or close to its natural resonant frequency;

a feedback control block that enables the second mechanical resonator to resonate along the pre-selected axis at or close to its natural resonant frequency;

a control loop that enables the phase-lock between the resonance of the first mechanical resonator and the resonance of the second mechanical resonator with certain preset phase difference by detecting the phase difference between the resonances and accordingly adjusting the natural resonant frequency of

the second mechanical resonator through the frequency adjustment mechanism of the second mechanical resonator.

[c3] 3. A mechanical resonator pair according to Claim 1, wherein:

The resonating mass of the first mechanical resonator is a movable structure suspended over a substrate and supported by a set of mechanical beams, with at least one point of each of the mechanical beams anchored on the substrate;

The driving mechanism of the first mechanical resonator is implemented by an electrostatic force applied on the resonating mass of the first mechanical resonator through a set of electrodes placed near the resonating mass of the first mechanical resonator and anchored on the substrate;

The driving feedback mechanism of the first mechanical resonator is implemented by capacitive sensing with one or more capacitors formed by the resonating mass of the first mechanical resonator and a set of electrodes placed near the resonating mass of the first mechanical resonator and anchored on the substrate;

The resonating mass of the second mechanical resonator is a movable structure suspended over the same substrate of the first mechanical resonator and supported by

a set of mechanical beams, with at least one point of each of the mechanical beams anchored on the substrate;

The driving mechanism of the second mechanical resonator is implemented by an electrostatic force applied on the resonating mass of the second mechanical resonator through a set of electrodes placed near the resonating mass of the second mechanical resonator and anchored on the substrate;

The driving feedback mechanism of the second mechanical resonators is implemented by capacitive sensing with one or more capacitors formed by the resonating mass of the second mechanical resonator and a set of electrodes placed near the resonating mass of the second mechanical resonator and anchored on the substrate;

The frequency adjustment mechanism of the second mechanical resonator is implemented by an electrostatic force applied on the resonating mass of the second mechanical resonator through a set of electrodes placed near the resonating mass of the second mechanical resonator and anchored on the substrate, with the electrostatic force having a component that is linear to the relative position of the resonating mass of the second mechanical resonator and the substrate;

[c4] 4. A mechanical resonator pair according to Claim 2, wherein:

The resonating mass of the first mechanical resonator is a movable structure suspended over a substrate and supported by a set of mechanical beams, with at least one point of each of the mechanical beams anchored on the substrate;

The driving mechanism of the first mechanical resonator is implemented by an electrostatic force applied on the resonating mass of the first mechanical resonator through a set of electrodes placed near the resonating mass of the first mechanical resonator and anchored on the substrate;

The driving feedback mechanism of the first mechanical resonator is implemented by capacitive sensing with one or more capacitors formed by the resonating mass of the first mechanical resonator and a set of electrodes placed near the resonating mass of the first mechanical resonator and anchored on the substrate;

The resonating mass of the second mechanical resonator is a movable structure suspended over the same substrate of the first mechanical resonator and supported by a set of mechanical beams, with at least one point of each of the mechanical beams anchored on the substrate;

The driving mechanism of the second mechanical res-

onator is implemented by an electrostatic force applied on the resonating mass of the second mechanical resonator through a set of electrodes placed near the resonating mass of the second mechanical resonator and anchored on the substrate;

The driving feedback mechanism of the second mechanical resonators is implemented by capacitive sensing with one or more capacitors formed by the resonating mass of the second mechanical resonator and a set of electrodes placed near the resonating mass of the second mechanical resonator and anchored on the substrate;

The frequency adjustment mechanism of the second mechanical resonator is implemented by an electrostatic force applied on the resonating mass of the second mechanical resonator through a set of electrodes placed near the resonating mass of the second mechanical resonator and anchored on the substrate, with the electrostatic force having a component that is linear to the relative position of the resonating mass of the second mechanical resonator and the substrate;

The control loop of the circuitry is implemented by a loop that comprises at least a phase-detector, a low-pass filter, and the feedback control block that enables the second mechanical resonator to resonate along the pre-selected axis at or close to its natural resonant fre-

quency;

- [c5] 5. A mechanical resonator pair according to Claim 2, wherein:

The resonating masses of the first and second mechanical resonators are used as the resonating masses to generate the Coriolis force in a vibration gyroscope utilizing Coriolis Effect.

- [c6] 6. A vibration gyroscope utilizing Coriolis effect comprising, at least:

a first movable mass resonating at or close to its natural resonate frequency along a pre-selected axis, where the resonance of said first movable mass along said pre-selected axis is to generate the Coriolis force when there is a rotation about an axis that is perpendicular to said pre-selected axis;

a driving mechanism that drives the first movable mass to resonate along the pre-selected axis;

a driving feedback mechanism that provides status information of the resonance of the first movable mass along the pre-selected axis (such as amplitude, frequency, and phase of the resonance);

a second movable mass resonating at or close to its natural resonate frequency along the same pre-selected axis of the first movable mass, with its resonance phase-locked to the resonance of the first movable mass with

certain preset phase difference, preferably 180 degree or close to 180 degree;  
a driving mechanism that drives the second movable mass to resonate along the pre-selected axis;  
a driving feedback mechanism that provides status information of the resonance of the second movable mass along the pre-selected axis (such as amplitude, frequency, and phase of the resonance);  
a frequency adjustment mechanism that adjusts the natural resonant frequency of the second movable mass for the resonance along the pre-selected axis;

[c7] 7. A vibration gyroscope of Claim 6, further comprising:  
a circuitry that enables the phase-lock between the resonance of the first movable mass along the pre-selected axis and the resonance of the second movable mass along the pre-selected axis with certain preset phase difference comprising, at least:

- a feedback control block that enables the first movable mass to resonate along the pre-selected axis at or close to its natural resonant frequency;
- a feedback control block that enables the second movable mass to resonate along the pre-selected axis at or close to its natural resonant frequency;
- a control loop that enables the phase-lock between the resonance of the first movable mass along the



pre-selected axis and the resonance of the second movable mass along the pre-selected axis with certain preset phase difference, preferably 180 degree or close to 180 degree, by detecting the phase difference between the resonances and accordingly adjusting the natural resonant frequency of the second movable mass through the frequency adjustment mechanism of the second movable mass.

[c8] 8. A vibration gyroscope of Claim 6, wherein:

The first movable mass is a movable structure suspended over a substrate and supported by a set of mechanical beams, with at least one point of each of the mechanical beams anchored on the substrate;

The driving mechanism for the first movable mass is implemented by an electrostatic force between the first movable mass and a set of electrodes placed near the first movable mass and anchored on the substrate;

The driving feedback mechanism for the first movable mass is implemented by capacitive sensing with one or more capacitors formed by the first movable mass and a set of electrodes placed near the first movable mass and anchored on the substrate;

The second movable mass is a movable structure suspended over the same substrate of the first movable mass and supported by a set of mechanical beams, with

at least one point of each of the mechanical beams anchored on the substrate;

The driving mechanism for the second movable mass is implemented by an electrostatic force between the second movable mass and a set of electrodes placed near the second movable mass and anchored on the substrate;

The driving feedback mechanism for the second movable mass is implemented by capacitive sensing with one or more capacitors formed by the second movable mass and a set of electrodes placed near the second movable mass and anchored on the substrate;

The frequency adjustment mechanism for the second movable mass is implemented by an electrostatic force applied on the second movable mass through a set of electrodes placed near the second movable mass and anchored on the substrate, with the electrostatic force having a component that is linear to the relative position of the second movable mass and the substrate;

[c9] 9. A vibration gyroscope of Claim 7, wherein:

The first movable mass is a movable structure suspended over a substrate and supported by a set of mechanical beams, with at least one point of each of the mechanical beams anchored on the substrate;

The driving mechanism for the first movable mass is im-

plemented by an electrostatic force between the first movable mass and a set of electrodes placed near the first movable mass and anchored on the substrate;

The driving feedback mechanism for the first movable mass is implemented by capacitive sensing with one or more capacitors formed by the first movable mass and a set of electrodes placed near the first movable mass and anchored on the substrate;

The second movable mass is a movable structure suspended over the same substrate of the first movable mass and supported by a set of mechanical beams, with at least one point of each of the mechanical beams anchored on the substrate;

The driving mechanism for the second movable mass is implemented by an electrostatic force between the second movable mass and a set of electrodes placed near the second movable mass and anchored on the substrate;

The driving feedback mechanism for the second movable mass is implemented by capacitive sensing with one or more capacitors formed by the second movable mass and a set of electrodes placed near the second movable mass and anchored on the substrate;

The frequency adjustment mechanism for the second movable mass is implemented by an electrostatic force applied on the second movable mass through a set of

electrodes placed near the second movable mass and anchored on the substrate, with the electrostatic force having a component that is linear to the relative position of the second movable mass and the substrate;

The control loop of the circuitry is implemented by a loop that comprises at least a phase-detector, a low-pass filter, and the feedback control block that enables the second movable mass to resonate at or close to its natural resonant frequency along the pre-selected axis.